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Master's Paper

Unit Organization of the Topic HEAT AND ITS CONTROL

Submitted by

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CHAPTER I

PREPARATION FOR TEACHING THE UNIT

The nature of the problem. It is the purpose of this paper to apply the basic principles and procedures set forth in Fundamentals of Secondary School Teaching, by Roy O. Billett, and the course in the Unit Method as taught at Boston University, to the unit organization and classroom presentation of the topic, Heat and Its Control. The writer feels that this paper will help to show the desirability of the unit method, particularly with reference to meeting the individual differences of pupils.

Why this subject was chosen for study. Heat is a necessity of life and a part of everyone's environment. This topic correlates very well with the study of clothing and textiles which the present writer taught in conjunction with the unit, to aid in the horizontal growth of the pupils.

> Secondary school courses must be planned to provide pupil experiences which will produce optimal horizontal growth. Here, it need only be said in passing that this is the problem of correlation, fusion, integration, or horizontal articulation. It will not be solved by teachers who are themselves ignorant of the horizontal implications and applications of what they are teaching. It will be solved only when the concepts and skills acquired by the pupil in one course merge naturally and effectively with those acquired in his other courses, in his extracurricular activities, and in his out-of-school experiences. This integration of concepts and skills at any given level is horizontal growth.[1]

[1] Roy O. Billett, Fundamentals of Secondary School Teaching, (Boston, Houghton Mifflin Company, 1940), pp. 137-38.

The pupils. The following unit and unit assignment were planned for thirty pupils of an eighth-grade science class in the Harvey Wheeler School of West Concord, Massachusetts. In order to know each pupil in the class as an individual, cumulative records were studied and the following tests administered, scored, and studied: Iowa Silent Reading Tests (TABLE I), Kuder Preference Record (TABLE II), and the California Test of Personality (TABLE III).

One of the most important functions of the Iowa Silent Reading Tests lies in the fact that their use in a class provides the teacher with a rather exact estimate of the level of development of a number of important elements of silent reading abilities in the class, as well as with specific information in certain important skill areas concerning the limitations of the individuals comprising the class. From TABLE I you may gain the following information: the class is comprised of seventeen boys and thirteen girls, ages range from 13-3 to 15-1, intelligence quotients range from 87 to 125, medians cores in the Iowa Silent Reading Test range from 143 to 182, grade percentile from 8 to 93, grade equivalents from 6.0 to 14.1, and age equivalents range from 11-1 to 18-2. Without the above information it would be impossible to compile the References for Pupil's Use.

The Kuder Preference Record will show in percentiles their preference in nine general areas. TABLE II will show the following ranges in percentiles: Mechanical, 29 to 108; Computational, 9 to 54; Scientific, 34 to 90; Persuasive, 51 to 107; Artistic, 16 to 77; Literary, 21 to 90; Musical 1 to 44; Social Service, 41 to 117; and Clerical, 38 to 88.

The major purpose of the California Test of Personality is to reveal the extent to which the student is adjusting to the problems and conditions which confront him and is developing a normal, happy, and socially effective personality. TABLE III shows the following range in percentiles for this class: Self Adjustment, 1 to 85; Social Adjustment, 5 to 85; and Total Adjustment, 5 to 85.

TABLE IV gives the occupations and educational background of the parents. Fathers' occupations -- one of each of the following: doctor, machinist, fireman, storekeeper, iceman, banker, mill worker, postal clerk, boiler inspector, trucking business, painting contractor, farmer, mover, foreman, school teacher, insurance adjuster, chauffeur, and bookkeeper. There are also two laborers, three correction officers, and four truck drivers. Three fathers are deceased. Mothers' occupations -- one weaver, one clerk, twenty-seven housewives, and one deceased. The range in years of schooling -- fathers 4 to 18 and mothers 6 to 14.

TABLE I

IOWA SILENT READING TEST: FORM Am

PUPILS	SEX	AGE	I.Q. KUHLMANN ANDERSON	MEDIAN SCORE	GRADE PERCENT-ILE	GRADE EQUIVA-LENT	AGE EQUIVA-LENT
A	M	14-1	103	153	24	7.2	12-5
B	F	14-1	109	172	72	10.5	18-2
C	M	14-2	116	178	86	12.3	18-2
D	M	14-7	90	143	8	6.0	11-1
E	M	13-6	125	175	80	11.3	18-2
F	M	13-10	110	156	30	7.6	12-10
G	M	14-0	107	179	88	12.7	18-2
H	M	14-6	91	145	10	6.2	11-4
I	F	13-4	102	160	39	8.2	13-6
J	F	15-0	109	165	53	9.0	15-4
K	M	13-4	94	165	53	9.0	15-4
L	F	13-3	115	180	90	13.1	18-2
M	M	13-4	94	154	26	7.3	12-7
N	M	13-10	125	177	84	11.9	18-2
O	F	14-2	122	182	93	14.1	18-2
P	F	14-0	95	152	22	7.0	12-3
Q	M	14-2	94	154	26	7.3	12-7
R	F	13-6	104	150	18	6.8	12-0
S	F	13-5	108	169	64	9.8	18-2
T	F	14-2	110	167	59	9.4	16-8
U	F	13-3	125	170	66	10.0	18-2
V	M	13-6	125	180	90	13.1	18-2
W	M	14-7	90	160	39	8.2	13-6
X	F	14-2	107	174	77	11.0	18-2
Y	M	14-0	92	146	11	6.3	11-5
Z	M	15-1	87	147	13	6.4	11-7
AA	M	13-8	109	172	72	10.5	18-2
BB	F	13-3	112	161	42	8.3	13-9
CC	F	14-1	101	153	24	7.2	12-5
DD	M	13-4	110	167	59	9.4	16-8

TABLE II

KUDER PREFERENCE RECORD - PERCENTILES

PUPILS	MECHAN-ICAL	COMPUTA-TIONAL	SCIEN-TIFIC	PERSUA-SIVE	ARTIS-TIC	LITER-ARY	MUS-ICAL	SOC. SERV.	CLER-ICAL
A	108	24	59	62	49	37	29	79	39
B	29	23	50	69	66	60	41	51	67
C	84	39	61	67	45	41	8	74	62
D	102	25	61	67	50	39	36	72	43
E	39	47	73	81	16	60	44	109	64
F	78	20	90	67	40	47	7	55	55
G	92	29	83	64	70	36	1	69	51
H	108	36	54	51	39	21	32	78	43
I	58	25	62	55	49	38	16	103	59
J	47	26	40	69	76	26	36	74	63
K	72	32	79	53	42	44	10	88	46
L	56	54	34	51	77	24	15	79	84
M	99	22	73	64	69	36	17	50	38
N	64	9	74	97	41	33	33	58	49
O	43	26	43	76	56	21	37	117	38
P	49	45	47	69	59	40	21	69	88
Q	102	32	47	71	54	38	26	63	50
R	39	26	48	55	77	51	11	83	67
S	57	31	38	55	71	37	20	103	53
T	53	28	69	64	57	47	10	101	58
U	31	27	46	79	46	45	29	102	76
V	75	17	44	75	61	66	2	65	62
W	92	32	71	72	74	30	10	62	41
X	61	26	47	61	70	25	32	76	71
Y	56	34	51	73	67	37	20	41	68
Z	81	34	83	65	51	55	14	61	59
AA	87	15	79	107	34	90	15	68	43
BB	38	32	55	66	62	48	33	73	65
CC	50	36	66	57	51	27	17	114	50
DD	28	51	35	65	48	76	38	68	68

TABLE III

CALIFORNIA TEST OF PERSONALITY (Percentiles)

PUPILS	SELF ADJUSTMENT	SOCIAL ADJUSTMENT	TOTAL ADJUSTMENT
A	10	50	25
B	85	85	85
C	50	50	50
D	60	70	65
E	10	20	15
F	65	60	60
G	20	20	20
H	30	60	45
I	80	75	75
J	15	35	20
K	25	50	35
L	20	55	35
M	70	70	70
N	35	30	30
O	25	15	20
P	25	20	25
Q	30	25	25
R	35	60	45
S	10	50	25
T	30	75	50
U	20	45	30
V	15	25	20
W	10	35	20
X	60	75	70
Y	30	75	50
Z	75	60	70
AA	50	35	45
BB	5	30	10
CC	1	10	5
DD	5	5	5

TABLE IV

PARENTS - OCCUPATIONS & EDUCATIONAL BACKGROUND

	OCCUPATIONS		EDUCATION IN YEARS	
	FATHER	MOTHER	FATHER	MOTHER
A	Doctor	Housewife	18	12
B	Machinist	Housewife	7	10
C	Fireman	Housewife	10	9
D	Storekeeper	Deceased	12	12
E	Bookkeeper	Housewife	14	15
F	Iceman	Housewife	8	8
G	Banker	Housewife	12	12
H	Mill Worker	Housewife	4	6
I	Deceased	Weaver	12	12
J	Postal Clerk	Housewife	9	8
K	Boiler Inspector	Housewife	8	10
L	Deceased	Housewife	12	12
M	Trucking Business	Housewife	10	8
N	Painting Contractor	Housewife	12	12
O	Deceased	Housewife	14	12
P	Farmer	Housewife	8	9
Q	Mover	Housewife	8	10
R	Truck driver	Housewife	10	8
S	Foreman-R.R.	Clerk	14	14
T	Correction Officer	Housewife	12	12
U	Correction Officer	Housewife	12	12
V	School Teacher	Housewife	12	12
W	Truck driver	Housewife	10	12
X	Insurance Adjuster	Housewife	12	13
Y	Correction Officer	Housewife	12	12
Z	Truck driver	Housewife	8	8
AA	Truck driver	Housewife	8	10
BB	Chauffeur	Housewife	10	12
CC	Laborer	Housewife	5	9
DD	Laborer	Housewife	8	12

The classroom. The classroom is situated in a two-storey wooden building. The desks and chairs are attached to the floor in six rows each containing six desks and chairs. Excess blackboards have been removed and replaced by bulletin boards. For storage there is a closet large enough for science equipment. The only electrical outlet for the room is in this closet. See scale drawing of room, (FIGURE 1) and photograph, (FIGURE 2).

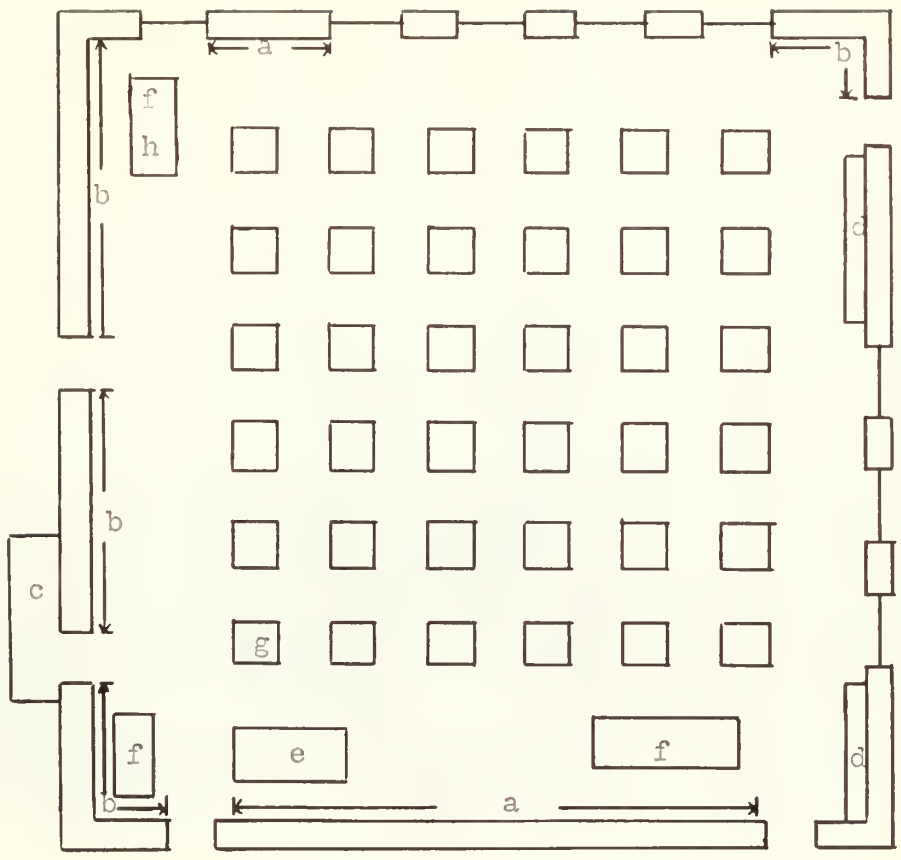


FIGURE 1 - Classroom

Scale of feet

0 . 4 . 8 . 12 . 16

Key

a. Blackboard
b. Bulletin board
c. Closet
d. Bookcase
e. Desk
f. Table
g. Pupil station
h. Filing cabinet

FIGURE 2 - SECTION OF CLASSROOM

Other views of classroom will be found in the appendix

Equipment and supplies. The Town of Concord has a building program in progress and as the above-mentioned building is to be torn down soon, only necessary repairs are accepted. However, every effort is made by the school department to furnish needed equipment and supplies. The audio-visual aids consist of: a lantern-slide projector, a film strip projector, an opaque projector, and a 16-mm.-sound film projector. Sound films and film strips were rented for certain dates and all necessary materials for heat experiments and for making lantern slides purchased.

The school office had an extra filing cabinet which was acquired for optional related activity cards. There were three tables that would be good for group work but only two chairs to use with them. A dozen old chairs were reconditioned by the manual training classes to make up the deficit.

A long extension cord was made so that audio-visual aids could be used and black shades added to the regular type made the room excellent for projection work.

The classroom library consists of forty-eight science books by different authors plus thirty-three of each of the following eighth-grade textbooks: Living with Science, by Morris Meister, and Science Problems for the Junior High School, by Wilbur L. Beauchamp. The latter was ordered by the writer to aid in the teaching of science by the unit method.

Pooling and sharing experiences. In this phase of the teaching learning cycle socialization and the audience situation was stressed. A pupil committee was formed a month before the unit was started.

They wrote for pamphlets and free materials on heat, insulation, and refrigeration. During the laboratory phase this group, in co-operation with the teacher, prepared a program for the pooling-of-experiences phase. This program consisted of the best individual summaries, experiments, explanations of drawings and exhibits, a field trip to the school heating plant, showing of movies and film strips, and was concluded by a class summary. FIGURE 3 shows the manufacture of oxygen by adding sodium peroxide to water. Heat is given off by the chemical action. (Other photographs of this phase are in the appendix).

FIGURE 3 - POOLING AND SHARING

Evaluation activities. In order to know what each pupil has achieved it is necessary to estimate his knowledge of a subject at the start of the unit during the laboratory and pooling-of-experiences phases, and at the conclusion of the unit. The present writer prepared an objective test which was given at the conclusion of the introductory phase and at the end of the unit as a final achievement test. The test consisted of one hundred questions of the true-false type and was based on the items of the delimitation. The test is set up in the following manner: the test items which measure item one of the delimitation come first and then a triple space followed by the test items which measure item two of the delimitation, and so on.

The results of the test which was given at the close of the unit show that many of the understandings covered by the delimitation were gained by the pupils. On the pre-test the range of scores was from 15 to 72. On the final test the range was from 58 to 90. The range of the gain of items answered correctly was from 11 to 62. These results may be seen in TABLE V.

TABLE V

OBJECTIVE TEST RESULTS

PUPILS	PRE-TEST SCORE	FINAL TEST SCORE	GAIN	PRE-TEST RANK	FINAL TEST RANK
A	42	63	21	14	17
B	50	80	30	9	4
C	57	77	20	5	6
D	41	62	21	15	18
E	15	77	62	22	6
F	72	83	11	1	3
G	68	80	12	2	4
H	36	63	27	18	17
I	42	72	30	14	10
J	35	75	40	19	8
K	45	70	25	12	13
L	55	73	18	7	9
M	44	71	27	13	11
N	47	80	33	11	4
O	49	71	22	10	11
P	29	61	32	21	19
Q	49	69	20	10	14
R	50	68	18	9	15
S	47	79	32	11	5
T	56	76	20	6	7
U	47	90	43	11	1
V	64	80	16	3	4
W	47	64	16	11	16
X	52	76	24	8	7
Y	35	64	29	19	16
Z	39	70	31	16	13
AA	63	85	22	4	2
BB	38	70	32	17	13
CC	31	58	27	20	20
DD	50	72	22	9	10

Teacher's log. To aid in the revision of the unit a log of the successes and failures, interests and disinterests, use of reference books, and other observable pupil responses was kept. As a check on the teacher's log each pupil was asked, at the conclusion of the unit, to answer a pupil-opinion poll on his reactions to the unit. The poll is on the following page. As a double check on the teacher's log each pupil handed in a card on which he listed the number of core and optional related activities he completed, reference books that were the most helpful, and suggestions as to other activities which might improve the unit. The results will be found in the Concluding observations.

Pupil-Opinion Poll (Encircle Yes or No)

1. Were all questions in the final exam mentioned in some way while studying the unit? Yes No
2. Was the final test too easy? Yes No
3. Do you enjoy using classroom references? Yes No
4. Did the unit meet all your needs? Yes No
5. Did this plan allow more or less "pupil activity"? Yes No
6. Were incorrect ideas kept very long before correction? Yes No
7. Did you find the optional work challenging? Yes No
8. Were the optional activities interesting? Yes No
9. Did the plan tend to encourage copying? Yes No
10. Was too much time spent on unimportant facts? Yes No
11. Were you able to study without waste of time? Yes No
12. Did you have some part in the pooling and sharing of experiences? Yes No
13. Were you able to understand the references studied? Yes No
14. Was the study guide a help to you? Yes No
15. Do you enjoy working at your own rate of speed? Yes No
16. Did the teacher help you much during the laboratory period? Yes No
17. Were the directions for study clear and helpful? Yes No
18. Is unit work better than the usual method? Yes No
19. Was there too much written work? Yes No
20. What did you enjoy most in the unit?

21. What did you dislike the most?

22. What did you find the easiest?

23. What did you find the hardest?

24. What did you find the most valuable?

CHAPTER II

General statement of the unit. Our everyday surroundings furnish us with many illustrations of the ways in which we make use of heat and heat-controlling devices. In the home we find such items as the fireplace, cooking range, furnace, water heater, refrigerator, thermometer, and thermostat. In the industries we find everywhere steam and gas engines, refrigerating machines, distilling devices, and various other heat mechanisms of greater or less importance to mankind. Thus we see that heat plays a very important part in the comfort and convenience of our lives.

Delimitation of the unit.

A. The nature of heat.

1. Heat is a form of energy.
2. The sun is the chief source of heat and light.
3. Small amounts of heat and light come to us from other heavenly bodies.
4. When a liquid is changed to a solid, heat is given off.
5. Heat is required to change a liquid to a gas.
6. Evaporation takes place at all temperatures. The higher the temperature, the more rapid the rate.
7. After water reaches the boiling point, additional heat is used to change the water to steam, but the temperature does not rise.
8. When a vapor condenses, heat is given out.
9. Oxydation is an especially important source of heat.

Rapid oxydation, which produces enough heat and light to be noticed, is called combustion.

10. The high temperatures inside the earth are thought to be caused, to a great extent, by the compression of the materials of the earth because of gravity.
11. Matter expands when heated and contracts when cooled.
12. Water can be changed from a solid (as ice) to a liquid (as water) and from a liquid to a gas or vapor (as steam) by heating it.
13. Most substances can be changed from one state to another, as water can, by being heated or cooled.
14. A fire cannot be started and will not continue to burn unless there is a combustible substance; a constant supply of oxygen; and some means of getting and keeping the fuel hot enough to burn.
15. Heat and light can be obtained from friction.
16. Electric energy is changed to heat energy because of the resistance of the conductor. The greater the resistance the greater the heat.
17. Heat can be taken from a body or added to it.
18. A body at a lower temperature may contain more heat than a smaller one at a higher temperature.

B. How heat is transferred.

1. Heat is always moving from places of higher temperature to places of lower temperature.
2. Heat moves right through materials by a process called

conduction; this process seems to be due to the more rapidly moving molecules striking against their neighbors and causing them to begin to move more rapidly.

3. Materials differ greatly in the rate at which heat is transferred through them. Iron and aluminum are very good conductors but materials such as cork and asbestos are very poor conductors, or insulators.
4. Fluids carry heat from one place to another by circulating under the influence of differences of temperature by a process called convection.
5. Heat moves through the space between warm objects and cooler ones by a process called radiation. In radiating it changes into radiant energy and then back again into heat when it is absorbed by another material.
6. Materials differ greatly in their ability to transmit and absorb radiant energy.
7. Fireplaces heat rooms mainly by radiation (except in the ventilating fireplace in which a convection current is set up).
8. Stoves heat rooms by all three methods of heat transfer.
9. Hot water and hot air furnaces heat by convection currents.
10. Steam furnaces transfer heat by forcing steam through pipes to radiators. When the steam condenses in the radiators it gives up a very large amount of heat to the air in the room.

C. How food is made cold and kept cold.

1. For a reason, not yet fully understood by scientists, the human being is not covered with a thick layer of hair as are most other warm-blooded animals. This results in our losing heat rapidly when the surrounding air becomes cold.
2. Whenever a solid is changed to a liquid, heat energy is required to pull the molecules away from each other, that is, heat is absorbed.
3. The heat required to change a liquid to a gas comes from surrounding materials, which are therefore cooled.
4. The more rapid the evaporation, the greater the cooling.
5. The less vapor there is in the space above a liquid, the more rapid the rate of evaporation.
6. Evaporation of a liquid removes heat from the liquid. When this is sufficiently rapid it may result in the freezing of the liquid.
7. Electric refrigerators freeze ice by securing the rapid evaporation of a liquid that removes heat from the water.
8. Cold storage plants are cooled by brine that has been cooled below freezing by the evaporation of liquid ammonia.
9. Brine is a concentrated solution of salt and water.

D. How our knowledge of heat is applied in clothing.

1. The more air spaces cloth contains in its weave, the less readily it conducts heat.
2. Most of our clothing is made of wool, cotton, linen,

silk, rayon, leather, fur, and rubber.

E. How buildings are constructed so as to consume heat.

1. Heat losses from buildings can be reduced by insulating materials that are poor conductors of heat and by tight construction.

2. Air-conditioning includes keeping the proper temperature, warm in winter and cool in summer; keeping the amount of water vapor at the correct level; and keeping the air free from dust.

F. How temperature is measured.

1. A thermostat is an automatic device for regulating temperature.

2. Temperature is a measure of how hot or cold an object is.

3. Temperatures are measured in degrees on a thermometer scale.

4. The temperature reading for the freezing point and the boiling point of water differs on the two kinds of thermometers, the Fahrenheit and the centigrade.

5. On the Fahrenheit thermometer the freezing point is 32 degrees and the boiling point is 212 degrees. On the centigrade thermometer the freezing point is 0 degrees and the boiling point is 100 degrees.

List of Probable Indirect and Incidental Learning Products.

A. Indirect.

1. The ability to work out a problem individually.

2. The attitude of working well with others.

B. Incidental.

1. The pupils will read about the advantages and disadvantages of different types of heating systems and refrigerators. This should make them better consumers in years to come.
2. In the unit many types of jobs connected with heat will be discussed. There is a possibility that one of the pupils might find an interest that would lead him to a vocation.
3. Increased skill in work-study habits.
4. Increased skill in the use of the classroom library and use of references.

List of materials and readings for teacher's use.

1. Billett, Roy O., Fundamentals of Secondary School Teaching. Boston: Houghton Mifflin Company, 1940.
2. Black, Newton H., and Harvey N. Davis, New Practical Physics. New York: The Macmillan Company, 1936.
3. Bode, Boyd H., Modern Educational Theories. New York: The Macmillan Company.
4. Jones, Arthur J., E. D. Grizzell, and Wren J. Grenstead, Principles of Unit Construction. New York: McGraw Hill Book Company.
5. Curtis, F. D., A Third Digest of Investigations in the Teaching of Science. Philadelphia: Blakiston Company, 1939.
6. Science Instruction and America's Problems. Washington, D. C.: Department of Science Instruction of the N. E. A., 1940.

7. Progressive Education Association, Science in General Education. New York: D. Appleton-Century Co., 1938.

8. Dale, Edgar, Audio-Visual Methods in Teaching. New York: The Dryden Press, 1947.

The unit assignment. (Tentative time allotment, four weeks, four periods per week).

A. Introduction: Have three pupils come to the front of the room, face the class, hold their right hands in front of them with palms up, and make them as cup-shape as possible. On one palm pour a little water, on the next pour a little alcohol and on the one remaining a little ether. Tell them to blow gently on their palms and to tell the class when the liquid is gone and how their palms feel. The liquids will evaporate in this order -- ether, alcohol, and water. The palm that had ether will feel very cold, the palm with alcohol will be cold, and the one that had water cooler than it was originally. Ask pupils why this has happened until someone gets the idea that evaporating liquids cool things and the more rapid the evaporation the greater the cooling. With a model gas refrigerator and the flame from an alcohol lamp demonstrate how a liquid is evaporated and then condensed to be evaporated again. Pupils then begin to understand how a flame can cause a refrigerator to keep food cool.

Discussion closes by passing out mimeographed study guides and telling the pupils that the guides will assist them in answering many more questions about heat.

B. Core activities:

1. Does an electric fan "cool the air"? Explain. (3b:241-242).
2. What happens to the molecules in a piece of iron when the iron is heated? (3b:261-265; 1b:101; 13:103-108).
3. Why do we put kindling under heavy fuels instead of on top of them? (1a: 256-258; 5a).
4. Explain why heat is considered a form of energy. (1a:320, 323, 335, 338; 1b:9; 3b:226, 241, 250-254, 273-275).
5. What type of clothing should we wear in cold weather? (16:154-155; 18:56).
6. Explain why heat always moves from places of higher temperature to places of lower temperature. (9:81).
7. What is the difference between a good conductor of heat and an insulator? List five of each. (1b:2, 4, 101-104; 3b:261-265, 302-304).
8. What is the chief source of heat and light? (2:250-253; 9:72-73; 10:98-99; 15:102).
9. Explain how fluids carry heat. (1a:170; 3b:266-267; 9:83-84).
10. What is radiation? (1b:10; 3b:268-270; 10:99; 11:84-85; 12:415-418).
11. Why is heat required to change a liquid to a gas? (3b:278-282; 20:302-306).
12. What do you mean when you say that a gas condenses? (3b:283-285).

13. Can you see steam? Explain.

14. Why do kitchen utensils such as spoons, often have their handles covered with wood or hard rubber? (3b:261-265; 16:69).

15. Why do you become warm when the sun is shining on you through window panes, even though the window panes remain cold? (3b:268-270; 17:242).

16. Why do you feel warmer on a hot day when the air is humid than on a hot day when the air is dry? (14:268; 3b:282).

17. Do 50 pounds of ice at 32° F. cool a refrigerator more than, less than, or the same amount as 50 pounds of water at 32° F.? Explain. (3b:273-275).

18. How is evaporation used in an electric refrigerator? (3b:299-301).

19. Tell briefly how a home can best be kept comfortable in both summer and winter. (3b:260, 302-304; 2:163-165; 8b).

20. How does a hot water heating system carry heat? (3b:290-291; 19:58, 256; 23:202-203).

21. How is artificial ice made? (3b:296-302).

22. Explain the advantages of air conditioning. (3b:302-304; 12:366, 399-402; 8a).

23. Tell why matter expands and contracts. (3a:141-144).

24. How does oxydation produce heat? (2:110; 3a:191; 26:168, 173, 174).

25. What is temperature? (2:115-119; 21:73; 24:361-366; 4a).

26. Explain how compression causes heat. (2:110; 3b:299-301).

27. What is a thermostat? How does it work? (3a:210-214).

28. What is the difference between Fahrenheit and centigrade thermometers? (3a:125-126).

29. What is needed to start a fire? (9:72-73).

30. Why is a tiled floor in your house colder than a wooden floor? (1b:100-103; 3b:262-266).

31. When you inflate a tire with a pump, the bottom of the piston chamber becomes hot. What are the two reasons for this heat? (2:110; 3b:236-237).

32. The metal cover of a fruit jar can often be loosened if hot water is poured on the metal. Explain. (1a:113-124; 22:256; 25:213).

33. Men employed by a telephone company are stringing wire between poles on a hot summer day. Should they allow a little slack in the wire, or should they stretch it as tightly as possible? Explain. (1a:113-124; 3b:141-144).

34. If you were boiling potatoes and wanted them to cook as fast as possible, would you make the water boil as hard as possible? (2:13; 3a:125-126, 131).

35. If it were not for the water trap in an ice refrigerator the cold air would fall out with the water from the melted ice. Explain. (2:151).

C. Optional related activities: (Post these activities by title on the bulletin board and describe them more fully in the card index).

1. Pupils volunteer for committees to do, with teacher

guidance, the following experiments. Directions are in text 3b:262-298.

a. How is a piece of metal heated?

b. How is heat transferred by radiation?

c. How is radiant energy changed to heat?

d. What happens when a mixture of ice and water is heated?

e. Does water keep getting colder while it is freezing?

f. Does an evaporating liquid take heat from the things around it?

g. Which can warm things more, boiling water or steam?

h. How can ice be made by evaporation?

2. Written report of some prepared topic or personal experience and experiments which can be done at home.

a. How is your house heated?

b. How does your refrigerator work?

c. Make a thermometer. (See teacher for materials and instructions).

d. See how low a temperature you can obtain by evaporating ether or alcohol from a cloth wrapped around the bulb of a thermometer.

e. Tack cloth all around a cubical wooden frame. Place a thermometer so that the bulb will be inside the inclosure. Wet the cloth and see how cool the inside of your "refrigerator" will get. Many campers use this plan for keeping food cool.

f. How can a single compressor in the basement keep

several refrigerators in a building cool?

g. Why is a fan not needed when the condensing coils are placed on top of the refrigerator?

h. The first thin coating of ice on a pond may form overnight, but after a long time the ice may be only an inch or two thick. Tell why the ice gets thicker slowly.

i. Why is a snow house good protection from cold weather in the arctic regions?

j. One man reported that painting his automobile top with aluminum paint made the car 10 degrees cooler on a sunny day. Do you think that this could be correct? Why?

k. Hold your finger in the jet of air as it escapes from the valve of an automobile tire. Does it feel hot or cold? Tell why.

3. Drawing.

a. Draw a hot air, hot water, and steam heating system.

b. Draw an electric refrigerator.

c. Make a drawing of air circulation in a room.

d. Make a lantern slide for any of the above drawings.

4. Collections and exhibits.

a. Volunteer to be a member of a bulletin-board-and-exhibit committee. Consult the teacher concerning the duties of this committee.

b. If you have a camera, take some pictures of anything related to this unit on heat. You may have a chance to show good pictures to the class by means of the opaque

projector.

c. Cut pictures from discarded magazines of heating, refrigerating, and air conditioning equipment. Make a scrapbook of these items.

d. Collect samples of good and bad conductors to display to the class.

D. List of materials and references for pupils' use.

1. Meister, Morris, Living With Science. New York: Charles Scribner's Sons, 1940.

a. Book I.

b. Book II.

2. Caldwell, Otis W., and Francis D. Curtis, Everyday Science. Boston: Ginn and Company, 1943.

3. Beauchamp, Wilbur L., John C. Mayfield and Joe C. West, Science Problems for the Junior High School. New York: Scott, Foresman and Company, 1946.

a. Book I.

b. Book II.

4. Eastman Classroom Films.

a. "Hot Air Heating."

b. "Refrigeration."

5. Erpi Classroom Films, Inc.: "Distributing Heat Energy."

6. Society for Visual Education: "Fire and Heat" - Filmstrip.

7. Samples of Materials - The Celotex Corporation: Samples of various kinds of wall-insulating materials.

8. Pamphlets.

a. The Carrier Corporation, 850 Frelinghuysen Ave., Newark, N. J.: "Illustrated Pamphlets on Air Conditioning."

b. The Celotex Corporation, 919 N. Michigan Ave., Chicago, Illinois: "Home Insulating."

9. Davis, Ira C., and Richard W. Sharpe, Science. New York: Henry Holt and Company, 1936.

10. Pieper, Charles and Wilbur L. Beauchamp, Everyday Problems in Science. New York: Scott, Foresman and Company, 1936.

11. Craig, Gerald S., and John Urban, Science Plans for Tomorrow. Boston: Ginn and Company.

12. Watkins, Ralph K., and Winifred Perry, Science for Human Control. New York: The Macmillan Co., 1940.

13. Beauchamp, Wilbur L., Glenn O. Blough, and Mary Melrose, Discovering Our World, Book II. New York: Scott, Foresman and Company, 1939.

14. Croxton, W. C., Science in the Elementary School. New York: McGraw-Hill Book Company, Inc., 1937.

15. Craig, Gerald S., and Beatrice D. Hurley, The Earth and Life Upon It. Boston: Ginn and Company, 1940.

16. Webb, Hanor A., and John J. Didcoct, Early Steps in Science. New York: D. Appleton & Co., 1927.

17. Craig, Gerald S., Margaret G. Cowdry, and Katherine E. Hill, From Sun to Earth. Boston: Ginn and Company, 1940.

18. Knox, Warren, George Stone, Morris Meister, and Doris Noble, The Wonderworld of Science. Book II. New York: Chas. Scribner's Sons,

1940.

19. Meister, Morris, Ralph E. Keirstead, and Lois N. Shoemaker, The Wonderworld of Science. Book VII. New York: Charles Scribner's Sons, 1947.

20. Watkins, Ralph K. and Winifred Perry, Understanding Science. New York: The Macmillan Co., 1940.

21. Pulvermacher, William Dean, and Charles H. Vosburgh, The World About Us. Boston: D. C. Heath and Company, 1930.

22. Gruenberg, Benjamin C., Science In Our Lives. New York: World Book Co., 1938.

23. Hodgdon, Daniel R., and Morris Nelson Sachs, Creative Science. New York: Hinds, Hayden and Eldredge, Inc., 1939.

24. Fowler, George W., Morton C. Collister, and Ernest L. Thurston, Our Surroundings. New York: The Iroquois Publishing Company, 1948.

25. Weed, Henry T., and Frank A. Rexford, Useful Science. Philadelphia: John C. Winston Co., 1931.

26. Craig, Gerald S., Science for the Elementary School Teacher. Boston: Ginn and Company, 1948.

E. Objective test. Directions: Read each statement carefully. If you think the statement is true pencil a circle around the number of the statement. If you think it is false make an X through the number of the statement. Mark each statement, and put a question mark in front of the number if you are very much in doubt about the correct answer. Remember, if any part of the statement is false, the statement as a whole is false.

1. Heat is a form of energy.
2. Early scientists believed that heat was a fluid.
3. Coal is the world's chief source of heat.
4. We get some heat and light from stars.
5. When a liquid is changed to a solid, heat is absorbed.
6. When a tub of water in the cellar freezes it warms the cellar.
7. Heat is required to change a liquid to a gas.
8. Evaporation takes place at all temperatures.
9. The lower the temperature, the more rapid the rate of evaporation.
10. After water reaches the boiling point additional heat will change the water to steam.
11. Adding heat to boiling water will increase its temperature.
12. Almost everyone has seen steam coming from a kettle.
13. When a vapor condenses, heat is absorbed.
14. Warm air can hold more moisture than cool air.
15. Oxydation is an important source of heat.
16. Oxydation cannot be seen with the naked eye.
17. Rapid oxydation is called combustion.
18. The high temperatures in the center of the earth are caused by fires in coal mines.
19. Gravity causes high temperature inside the earth.

20. Matter expands when heated and when cooled.

21. Electric light men put more slack in wires they put up in winter than they do in the summer.

22. To loosen a metal cover on a jar we should pour hot water on it.

23. When air expands it becomes cooler.

24. Water can be changed from a solid to a liquid and from a liquid to a gas by heating it.

25. All substances can be changed from one state to another by being heated or cooled.

26. Fire cannot be started and will not continue to burn unless there is a combustible substance.

27. Hard wood is better than soft wood for starting a fire.

28. Oxygen is only needed to start a fire and can be eliminated when it gets going good.

29. Fuel must be kept hot enough to burn.

30. Heat and light can be obtained from friction.

31. The less electrical resistance in a conductor the greater the heat.

32. Electric currents can produce heat.

33. Electric currents can produce freezing.

34. Oil furnaces do not need electric currents.

35. Heat can be taken from a body but not added to it.

36. A body at a lower temperature may contain more heat than a smaller one at a higher temperature.

37. A match flame contains more heat than a tub of hot water suitable for bathing.

38. Heat always moves from places of lower temperature to places of higher temperature.

39. Heat moves through materials by a process called conduction.

40. Heat causes the molecules in a material to slow down.

41. Molecules in cold metal move rapidly.

42. Materials differ greatly in the rate at which heat is transferred through them.

43. A good conductor of heat is called an insulator.

44. Fluids carry heat from one place to another by a process called convection.

45. Fluids circulate due to the influence of different temperatures.

46. Heat moves through the space between warm objects and cooler ones by conduction.

47. Radiant energy is warm.

48. In radiating heat changes into radiant energy and then back again into heat when it is absorbed by another material.

49. Materials differ greatly in their ability to transmit radiant energy.

50. Materials are the same in their ability to absorb radiant energy.

51. Old-fashioned fireplaces heat rooms mainly by radiation.

52. In the new-type ventilating fireplaces a convection current is set up.

53. Stoves heat rooms by all three methods of heat transfer.

54. A good stove is completely insulated.

55. Hot water and hot air furnaces heat by convection currents.

56. Steam furnaces transfer heat by conduction.

57. Steam furnaces are well insulated.

58. You should keep the water gauge of a steam furnace full at all times.

59. Steam condenses in radiators.

60. Man is a warm-blooded animal.

61. Our body does not give heat to the air.

62. When a solid is changed to a liquid heat energy is required.

63. When a solid is changed to a liquid heat is absorbed.

64. The heat required to change a liquid to a gas comes from surrounding materials, which are therefore cooled.

65. The slower the evaporation, the greater the cooling.

66. Water evaporates more slowly than alcohol.

67. Ether evaporates more quickly than alcohol.

68. The more vapor there is in the space above a liquid the more rapid the rate of evaporation.

69. We feel warmer on a hot day when the air is humid than on a hot day when the air is dry.

70. Moisture in the air is measured by an altimeter.

71. Evaporation of a liquid removes heat from the liquid.

72. Rapid evaporation causes freezing.

73. Your hands and face become colder quickly when they are wet.

74. Electric refrigerators freeze ice by having slow evaporation.

75. An ice box in which the ice couldn't melt would make a great many people happy.

76. Electric refrigerators need fans to circulate the air unless the freezing unit is at the top.

77. Cold storage plants are cooled by brine.

78. Brine can be cooled below freezing by the evaporation of liquid ammonia.

79. Brine is a concentrated solution of salt and water.

80. Cotton is as warm for clothing as wool.

81. Wool is better than either cotton or silk for winter wear because it can be woven more loosely.

82. Most of our clothing comes from plants or animals.

83. Heat losses from buildings can be increased by good insulation.

84. Houses of tight construction lower your fuel bills.

85. There should be no dead-air space in buildings.

86. Air conditioning equipment keeps the temperature warm in winter and cool in summer.

87. Air conditioning keeps the corect amount of water vapor in the air.

88. Air conditioning keeps the air free from dust.

89. A thermostat is an automatic device for regulating temperature.

90. Thermostats should be placed as near to a furnace as possible.

91. Temperature is a measure of how hot or cold an object is.

92. The normal temperature of most people is 100° F.

93. Temperature is measured in inches on a thermometer.

94. The temperature reading for the freezing point and the boiling point of water differs on the two kinds of thermometers, the Fahrenheit and the centigrade.

95. Scientists in this country usually use the Fahrenheit thermometer.

96. The number of degrees between freezing and boiling is greater on the centigrade thermometer.

97. Zero° is the freezing point on the centigrade scale.

98. The melting point of ice is the same as the freezing point of water.

99. Water boils at 221° F.

100. On the Fahrenheit thermometer the space on the tube between the boiling point and the freezing point is divided into 180 equal parts.

CHAPTER III

EVALUATION OF THE UNIT[1]

Results of objective testing. For the purpose of guidance, it is necessary to know a pupil's relative growth as well as his actual growth. To do this his actual growth must be compared with the actual growth of other pupils and with the average growth of the class. It is now the procedure to classify pupils into the following relative-growth groups: Group I, of pupils who made outstanding growth; Group II, of pupils who made above average growth; Group III, of pupils who made average growth; Group IV, of pupils who made below average growth; and Group V, of pupils who made inferior growth.

To calculate the relative-growth groups of the class tested the statistical procedures for finding the arithmetic mean and the standard deviation were used. The arithmetic mean indicates the average growth of the class and the standard deviation tends to point out the amount of spread or dispersion of the pupil's growth as it deviates from the mean. Tables VI, VII, and VIII show the arithmetic means and standard deviations of the total scores on the pre-test, final test, and the gain respectively.

It should be noticed that the arithmetic mean of the scores on the pre-test was 46 as compared with the arithmetic mean of 72 on the final test. The standard deviation on the pre-test was 12 as compared with the standard deviation of eight on the final test.

[1] Following suggestion in Chapter XX of Roy O. Billett, Fundamentals of Secondary School Teaching, (Boston, Houghton Mifflin Company, 1940).

The total scores of the thirty pupils in relative-growth scales may be seen for the pre-test, final test, and gain in FIGURES 4, 5, and 6. Due to the fact that one pupil made a score of 15 in the pre-test and 77 in the final test, a gain of 62, the relative-growth scales for pre-test and gain do not group him within two and one-half standard deviations from the mean. However, the growth of these pupils in the final test (FIGURE 5) was distributed in accordance with the normal distribution curve.

TABLE VI shows that the mean for the pre-test was 46.5 or 46 for all practical purposes, and the standard deviation 11.5 or 12. FIGURE 4 shows the relative-growth scale for the pre-test to be: Group I, 3 pupils; Group II, 5 pupils; Group III, 14 pupils; Group IV, 7 pupils; Group V, none; and one pupil more than two and one-half standard deviations below the mean.

TABLE VI

CALCULATION OF THE MEAN AND STANDARD DEVIATION - PRE-TEST

RAW SCORES INTERVALS OF FIVE	TALLIES	F	D	FD	FD^2
70-74		1	+5	5	25
65-69		1	+4	4	16
60-64		2	+3	6	18
55-59		3	+2	6	12
50-54		4	+1	4	4
45-49		7	0	0	0
40-44		4	-1	-4	4
35-39		5	-2	-10	20
30-34		1	-3	-3	9
25-29		1	-4	-4	16
20-24		0	-5	0	0
15-19		1	-6	-6	36
Totals	30	30		-3	160

M = A.M. - (Sum of FD ÷ N) X Class Interval

M = 47 - (-3 ÷ 30) X 5

M = 47 - (-.1) X 5

M = 47 - .5

M = 46.5 or (46 for all practical purposes)

1. $S.D. = \sqrt{\frac{\text{Sum of } FD^2}{N} - \left(\frac{\text{Sum of } FD}{N}\right)^2} \times \text{Size of Class Interval}$

2. $S.D. = \sqrt{\frac{160}{30} - \frac{(-3)^2}{(30)}} \times 5$

$S.D. = \sqrt{5.33 - .1} \times 5$

$S.D. = \sqrt{5.23} \times 5$

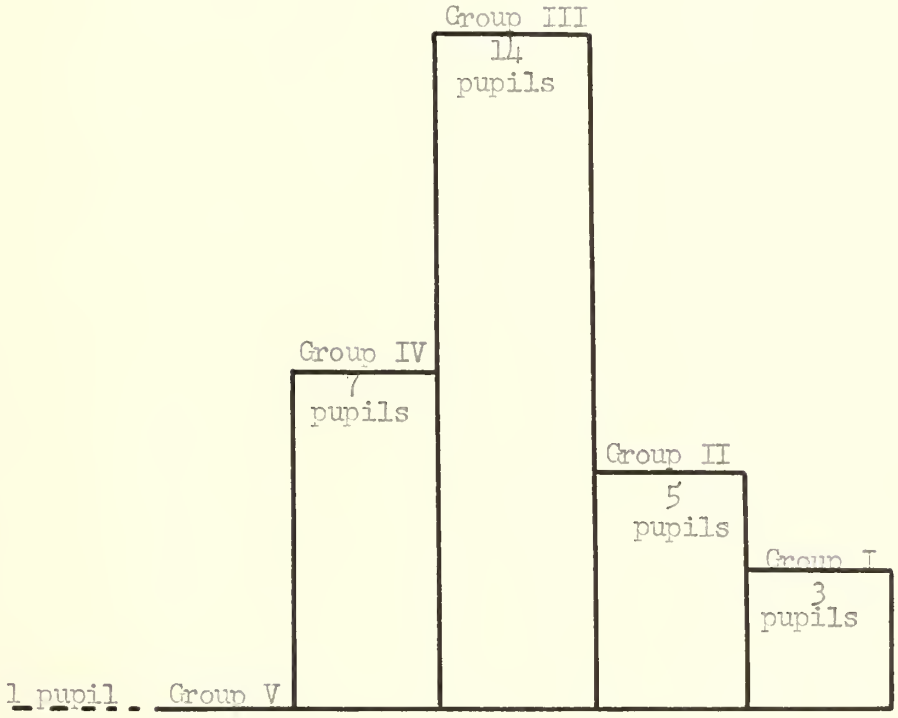
$S.D. = 2.29 \times 5$

S.D. = 11.5 or 12

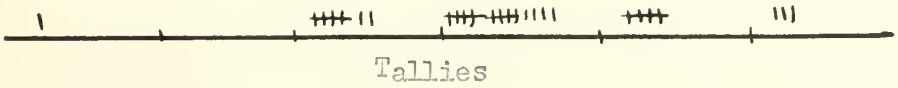
FIGURE 4

RELATIVE-GROWTH SCALE

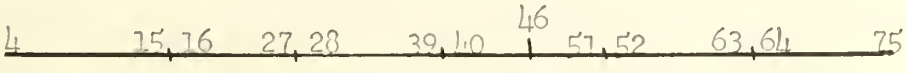
(Pre-test)



ACTUAL DISTRIBUTION OF PUPIL GROWTH



Tallies



RELATIVE-GROWTH SCALE

TABLE VII shows the mean and standard deviation of the final test to be 72 and 8, respectively. FIGURE 5, the relative-growth scale for the final test, shows the following distribution of pupil growth: Group I, 2 pupils; Group II, 8 pupils; Group III, 12 pupils; Group IV, 7 pupils; and Group V, 1 pupil.

TABLE VII

CALCULATION OF THE MEAN AND STANDARD DEVIATION

FINAL TEST

RAW SCORES INTERVALS OF THREE	TALLIES	F	D	FD	FD^2
90-92		1	+6	6	36
87-89		0	+5	0	0
84-86		1	+4	4	16
81-83		1	+3	3	9
78-80		5	+2	10	20
75-77		5	+1	5	5
72-74		3	0	0	0
69-71		6	-1	-6	6
66-68		1	-2	-2	4
63-65		4	-3	-12	36
60-62		2	-4	-8	32
57-59		1	-5	-5	25
Totals	30	30		-5	189

M = A.M. - (Sum of FD ÷ N) X Class Interval

M = 73 - (-5 ÷ 30) X 3

M = 73 - (-.17) X 3

M = 73 - .51

M = 72.49 or (72 for all practical purposes)

1. $S.D. = \sqrt{\frac{\text{Sum of } FD^2}{N} - \left(\frac{\text{Sum of FD}}{N}\right)^2}$ X Size of Class Interval

2. $S.D. = \sqrt{\frac{189}{30} - \frac{(-5)^2}{(30)}}$ X 3

$S.D. = \sqrt{6.3 - .03}$ X 3

$S.D. = \sqrt{6.27}$ X 3

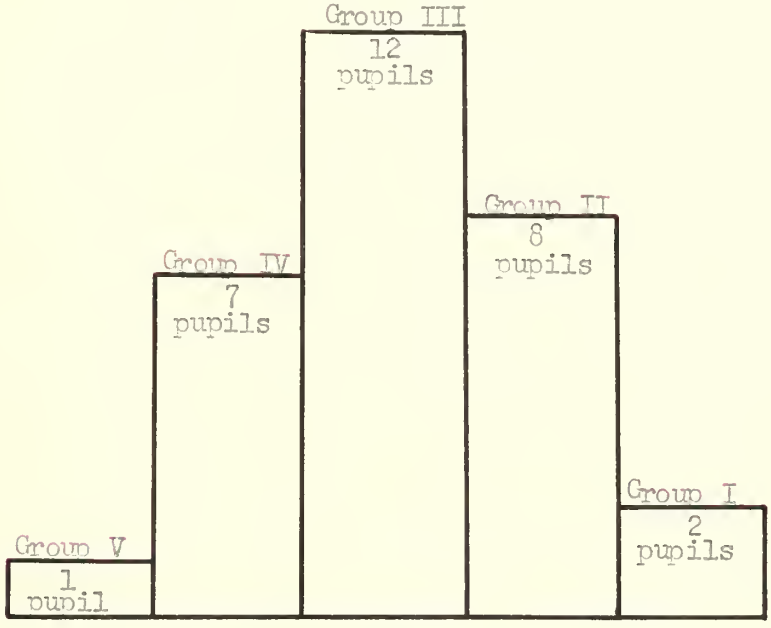
S.D. = 2.5 X 3

S.D. = 7.5 or 8

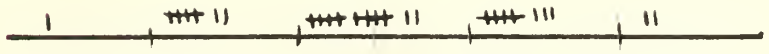
FIGURE 5

RELATIVE-GROWTH SCALE

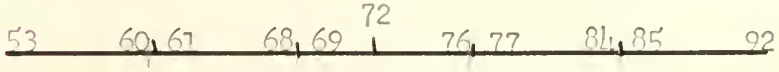
FINAL TEST



ACTUAL DISTRIBUTION OF PUPIL GROWTH



TALLIES



RELATIVE-GROWTH SCALE

TABLE VIII calculates the mean and standard deviation for the gain. The mean is 26 and the standard deviation 11. FIGURE 6 shows the distribution of pupil growth for the gain to be : Group I, 1 pupil; Group II, 5 pupils; Group III, 14 pupils; Group IV, 9 pupils; Group V, none; and one pupil more than two and one-half standard deviation above the mean.

TABLE VIII

CALCULATION OF THE MEAN AND STANDARD DEVIATION

GAIN

RAW SCORES INTERVALS OF FIVE	TALLIES	F	D	FD	FD^2
62-66		1	+8	8	64
57-61		0	+7	0	0
52-56		0	+6	0	0
47-51		0	+5	0	0
42-46		1	+4	4	16
37-41		1	+3	3	9
32-36		4	+2	8	16
27-31		7	+1	7	7
22-26		5	0	0	0
17-21		7	-1	-7	7
12-16		3	-2	-6	12
7-11		1	-3	-3	9
Totals	30	30		14	140

M = A.M. - (Sum of FD ÷ N) X Class Interval

M = 24 - (14 ÷ 30) X 5

M = 24 - (.47) X 5

M = 24 - 2.35

M = 26.35 or (26 for all practical purposes)

1. $S.D. = \sqrt{\frac{\text{Sum of } FD^2}{N} - \left(\frac{\text{Sum of FD}}{N}\right)^2}$ X Size of Class Interval

2. $S.D. = \sqrt{\frac{140}{30} - \left(\frac{14}{30}\right)^2}$ X 5

$S.D. = \sqrt{4.67 - .22}$ X 5

$S.D. = \sqrt{4.45}$ X 5

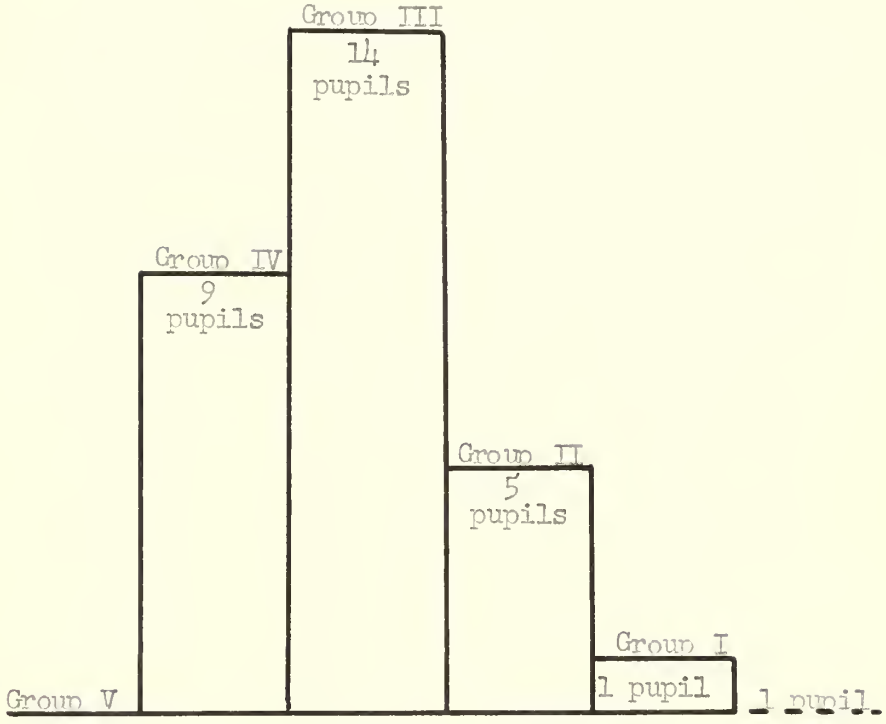
S.D. = 2.11 X 5

S.D. = 10.55 or (11 for all practical purposes)

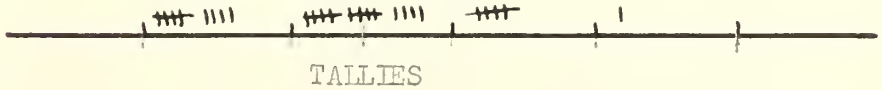
FIGURE 6

RELATIVE-GROWTH SCALE

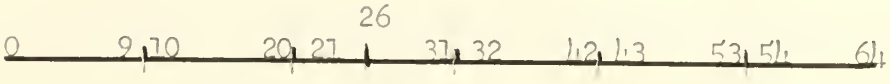
GAIN



ACTUAL DISTRIBUTION OF PUPIL GROWTH



TALLIES



RELATIVE-GROWTH SCALE

TABLE IX

RESULTS OF PUPIL-OPINION POLL

QUESTIONS NUMBER	ANSWERS YES	NO
1	28	2
2	0	30
3	29	1
4	30	0
5	30	0
6	3	27
7	29	1
8	29	1
9	4	26
10	1	29
11	28	2
12	30	0
13	29	1
14	30	0
15	30	0
16	26	4
17	30	0
18	29	1
19	2	28
20	Experiments 21, Drawing 5, Questions 4	
21	Nothing 3, Test 23, Questions 4	
22	Drawing with opaque projector 21, Experiments 9	
23	Test 26, Answering questions 4	
24	Experiments 4, Test 1, Bibliography 17, Looking up answers to questions 8	

Concluding observations. The results of the pupil-opinion poll, TABLE IX, show that the class of thirty pupils agree by a large majority to the following statements:

1. All questions in the final exam were mentioned in some way during the unit.
2. The final test was not too easy.
3. Pupils enjoyed using classroom references.
4. The unit met all of their needs.
5. The plan allowed more pupil activity.
6. Incorrect ideas were not kept long before correction.
7. Optional work was challenging.
8. Optional activities were interesting.
9. The plan did not tend to encourage copying.
10. Too much time was not spent on unimportant facts.
11. Pupils were able to study without waste of time.
12. All had part in the pooling and sharing phase.
13. References were understandable.
14. The study guide was a big help.
15. Pupils enjoyed working at their own rate of speed.
16. The teacher was a help during the laboratory phase.
17. Directions for study were clear and helpful.
18. Unit work is better than the usual method.
19. There was not too much written work.

Questions 20 to 24 receive the following responses:

20. What did you enjoy most in the unit?

Experiments 21, Drawing 5, Questions 4

Boston University
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21. What did you dislike the most?

Test 23, Questions 4, Nothing 3.

22. What did you find the easiest?

Drawing with opaque projector 21, Experiments 9.

23. What did you find the hardest?

Test 26, Answering questions 4.

24. What did you find the most valuable?

Bibliography 17, Looking up answers to questions 8, Experiments 4, Test 1.

The references used the most in this unit and found the most valuable for this class are listed below:

1. Beauchamp, Wilbur L., Science Problems for the Junior High School.

2. Caldwell, Otis W., Everyday Science.

3. Meister, Morris, Living With Science.

After teaching the unit the present writer believes that the material in the unit on refrigeration should be taken out and made into a separate unit, which could be taught directly after the unit on heat. This would allow the pupils to concentrate on the heat unit, take the test, and then use this knowledge in the unit on refrigeration. This suggestion applies to Junior High School classes.

It is evident from the writer's observations and the pupils' expressions that the most fruitful, effective way of organizing the instructional program is by the unit method. The results of the final test show advances which indicate definite educative growth. Pupils expressed that there was more opportunity for freedom of thought and

action and enjoyed progress at their individual rate of learning. The pupils realized that the unit approximated real lifelike situations and the wide variety of activities gave everyone an opportunity to do as well as think.

The unit method overcomes the weaknesses of the subject-matter unit of the past. However, to be effective the unit method must satisfy pupil needs, provide opportunity for experience in group work and practising the ways of democracy, and provide for continuous sharing of experiences in an atmosphere of co-operative effort.

Directions: Read each statement carefully. If you think the statement is true, pencil a circle around the number of the statement. If you think it is false, make an X through the number of the statement. Mark each statement, and put a question mark in front of the number if you are very much in doubt about the correct answer. Remember, if any part of the statement is false, the statement as a whole is false.

1. Heat is a form of energy.
2. Early scientists believed that heat was a fluid.
3. Coal is the world's chief source of heat.
4. We get some heat and light from stars.
5. When a liquid is changed to a solid, heat is absorbed.
6. When a tub of water in the cellar freezes it warms the cellar.
7. Heat is required to change a liquid to a gas.
8. Evaporation takes place at all temperatures.
9. The lower the temperature, the more rapid the rate of evaporation.
10. After water reaches the boiling point additional heat will change the water to steam.
11. Adding heat to boiling water will increase its temperature.
12. Almost everyone has seen steam coming from a kettle.
13. When a vapor condenses, heat is absorbed.
14. Warm air can hold more moisture than cool air.
15. Oxydation is an important source of heat.
16. Oxydation cannot be seen with the naked eye.
17. Rapid oxydation is called combustion.

18. The high temperatures in the center of the earth are caused by fires in coal mines.

19. Gravity causes high temperature inside the earth.

20. Better expands when heated and when cooled.

21. Electric light men put more slack in wires they put up in winter than they do in the summer.

22. To loosen a metal cover on a jar we should pour hot water on it.

23. When air expands it becomes cooler.

24. Water can be changed from a solid to a liquid and from a liquid to a gas by heating it.

25. All substances can be changed from one state to another by being heated or cooled.

26. Fire cannot be started and will not continue to burn unless there is a combustible substance.

27. Hard wood is better than soft wood for starting a fire.

28. Oxygen is only needed to start a fire and can be eliminated when it gets going good.

29. Fuel must be kept hot enough to burn.

30. Heat and light can be obtained from friction.

31. The less electrical resistance in a conductor the greater the heat.

32. Electric currents can produce heat.

33. Electric currents can produce freezing.

34. Oil furnaces do not need electric currents.

35. Heat can be taken from a body but not added to it.

36. A body at a lower temperature may contain more heat than a similar one at a higher temperature.

37. A match flame contains more heat than a tub of hot water suitable for bathing.

38. Heat always moves from places of lower temperature to places of higher temperature.

39. Heat moves through materials by a process called conduction.

40. Heat causes the molecules in a material to slow down.

41. Molecules in cold metal move rapidly.

42. Materials differ greatly in the rate at which heat is transferred through them.

43. A good conductor of heat is called an insulator.

44. Fluids carry heat from one place to another by a process called convection.

45. Fluids circulate due to the influence of different temperatures.

46. Heat moves through the space between warm objects and cooler ones by conduction.

47. Radiant energy is warm.

48. In radiating heat changes into radiant energy and then back again into heat when it is absorbed by another material.

49. Materials differ greatly in their ability to transmit radiant energy.

50. Materials are the same in their ability to absorb radiant energy.

51. Old fashioned fireplaces heat rooms mainly by radiation.

52. In the new-type ventilating fireplaces a convection current is set up.

53. Stoves heat rooms by all three methods of heat transfer.

54. A good stove is completely insulated.

55. Hot water and hot air furnaces heat by convection currents.

56. Steam furnaces heavily used in residences.

57. Steam furnaces are well insulated.

58. You should keep the water gauge of a steam furnace full at all times.

59. Steam condenses in radiators.

60. Man is a warm-blooded animal.

61. Our body does not give heat to the air.

62. When a solid is changed to a liquid heat energy is required.

63. When a solid is changed to a liquid heat is absorbed.

64. The heat required to change a liquid to a gas comes from surrounding materials, which are therefore cooled.

65. The slower the evaporation, the greater the cooling.

66. Water evaporates more slowly than alcohol.

67. Ether evaporates more quickly than alcohol.

68. The more vapor there is in the space above a liquid the more rapid the rate of evaporation.

69. We feel warmer on a hot day when the air is humid than on a hot day when the air is dry.

70. Moisture in the air is measured by an altimeter.

71. Evaporation of a liquid removes heat from the liquid.

72. Rapid evaporation causes freezing.

73. Your hands and face become colder quickly when they are wet.

74. Electric refrigerators freeze ice by having slow evaporation.

75. An ice box in which the ice couldn't melt would make a great many people happy.

76. Electric refrigerators need fans to circulate the air unless the freezing unit is at the top.

77. Cold storage plants are cooled by brine.

78. Brine can be cooled below freezing by the evaporation of liquid ammonia.

79. Brine is a concentrated solution of salt and water.

80. Cotton is as warm for clothing as wool.

81. Wool is better than either cotton or silk for winter wear because it can be woven more loosely.

82. Most of our clothing comes from plants or animals.

83. Heat losses from buildings can be increased by good insulation.

84. Houses of tight construction lower your fuel bills.

85. There should be no dead-air space in buildings.

86. Air conditioning equipment keeps the temperature warm in winter and cool in summer.

87. Air conditioning keeps the correct amount of water vapor in the air.

88. Air conditioning keeps the air free from dust.

89. A thermostat is an automatic device for regulating temperature.

90. Thermostats should be placed as near to a furnace as possible.

91. Temperature is a measure of how hot or cold an object is.

92. The normal temperature of most people is 100° F.

93. Temperature is measured in inches on a thermometer.

94. The temperature reading for the freezing point and the boiling point of water differs on the two kinds of thermometers, the Fahrenheit and the centigrade.

95. Scientists in this country usually use the Fahrenheit thermometer.

96. The number of degrees between freezing and boiling is greater on the centigrade thermometer.

97. Zero^{o} is the freezing point on the centigrade scale.

98. The melting point of ice is the same as the freezing point of water.

99. Water boils at 221° F.

100. On the Fahrenheit thermometer the space on the tube between the boiling point and the freezing point is divided into 180 equal parts.

SCORE SHEET - UNIT HEAT

1.	T	34.	F	67.	T
2.	T	35.	F	68.	F
3.	F	36.	T	69.	T
4.	T	37.	F	70.	F
5.	F	38.	F	71.	T
6.	T	39.	T	72.	T
7.	T	40.	F	73.	T
8.	T	41.	F	74.	F
9.	F	42.	T	75.	F
10.	T	43.	F	76.	T
11.	F	44.	T	77.	T
12.	F	45.	T	78.	T
13.	F	46.	F	79.	T
14.	T	47.	F	80.	F
15.	T	48.	T	81.	T
16.	F	49.	T	82.	T
17.	T	50.	F	83.	F
18.	F	51.	T	84.	T
19.	T	52.	T	85.	F
20.	F	53.	T	86.	T
21.	F	54.	F	87.	T
22.	T	55.	T	88.	T
23.	T	56.	F	89.	T
24.	T	57.	T	90.	F
25.	F	58.	F	91.	T
26.	T	59.	T	92.	F
27.	F	60.	T	93.	F
28.	F	61.	F	94.	T
29.	T	62.	T	95.	F
30.	T	63.	T	96.	F
31.	F	64.	T	97.	T
32.	T	65.	F	98.	T
33.	T	66.	T	99.	F
		100.	T		

General Study and Activity Guide

Unit: "Heat and Its Control"

Pupil's Name _____

1. Does an electric [illegible] explain. ([illegible])

2. What happens to the molecules in a piece of iron when the iron is heated? (3b:261-265; 1b:101; 13:103-108)

3. Why do we put kindling under heavy fuels instead of on top of them? (1a:256-258; 5a)

4. Explain why heat is considered a form of energy. (1a:320, 385, 335, 338; 1b:9; 3b:226, 241, 250-254, 273-275)

5. What type of clothing should we wear in cold weather? (16:[illegible]-155; 18:56)

6. Explain why heat always moves from places of higher temperature to places of lower temperature. (9:81)

7. What is the difference between a good conductor of heat and an insulator? List five of each. (1b:2,4,101-104; 3b:261-265, 302-304)

8. What is the chief source of heat and light? (2:250-253; 9:72-73; 10:98-99; 15:102)

9. Explain how fluids carry heat. (1a:170; 3b:266-267; 9:83-84)

10. What is radiation? (1b:10; 3b:268-270; 10:99; 11:84-85; 12:415-418)

11. Why is heat required to change a liquid to a gas? (3b:278-282; 20:302-306)

12. What do you mean when you say that a gas condenses? (3b:283-285)

13. Can you see steam? Explain.

14. Why do kitchen utensils such as spoons often have their handles covered with wood or hard rubber? (3b:261-265; 16:69)

15. Why do you become warm when the sun is shining on you through window panes, even though the window panes remain cold? (3b:268-270; 17:242)

16. Why do you feel warmer on a hot day when the air is humid than on a hot day when the air is dry? (14:268; 3b:282)

17. Do 50 pounds of ice at 32° F. cool a refrigerator more than, less than or the same amount as 50 pounds of water at 32° F.? Explain. (3b:273-275)

18. How is evaporation used in an electric refrigerator? (3b:299-301)

19. Tell briefly how a home can best be kept comfortable in both summer and winter. (3b:260, 302-304; 2:163-165; 8b)

20. How does a hot water heating system carry heat? (3b:290-291; 19:[illegible]; 23:202-203)

21. How is artificial ice made? (3b:296-302)

22. Explain the advantages of air conditioning. (3b:302-304; 19:366, [illegible]-402; 8a)

23. Tell why matter expands and contracts. (3a:141-144)

24. How does oxydation produce heat? (2:110; 3a:191; 26:168, 173, 174)

25. What is temperature? (2:115-119; 21:73; 24:361-366; 4a)

26. Explain how compression causes heat. (2:110; 3b:299-301)

27. What is a thermostat? How does it work? (3a:210-214)

28. What is the difference between Fahrenheit and centigrade thermometers? (3a:125-126)

29. What is needed to start a fire? (9:72-73)

30. Why is a tiled floor in your house colder than a wooden floor? (16:[illegible]-203; 3b:262-266)

31. When you inflate a tire with a pump, the bottom of the piston chamber becomes hot. What are the two reasons for this heat? (2:110; 3b:[illegible])

32. The metal cover of a fruit jar can often be loosened if hot water is poured on the metal. Explain. (1a:113-124; 22:256; 25:213)

33. Two employees by a telephone company are stringing wire between poles on a very warm day. Should they allow a little slack in the wire, or should they stretch it as tightly as possible? Explain. (1a:113-124; [illegible])

34. If you were [illegible] [illegible] and [illegible] them to cook as [illegible] as possible would you [illegible] [illegible] as [illegible] as possible? ([illegible])

35. If it were not for the water trap in an ice refrigerator the cold air would fall out with the water from the melted ice. Explain. ([illegible])

[illegible]

1. [illegible]
   a. [illegible]
   b. Book II
2. Caldwell, Otis W., and Francis D. Curtis, Everyday Science. Boston: Ginn and Company, 1943.
3. Beauchamp, Wilbur L., John C. Mayfield and Joe Y. West, Science Problems for the Junior High School. New York: Scott, Foresman and Company, [illegible].
   a. Book I.
   b. Book II.
4. Eastman Classroom Films.
   a. "Hot Air Heating."
   b. "Refrigeration."
5. Erpi Classroom Films, Inc.: "Distributing Heat Energy."
6. Society for Visual Education: "Fire and Heat" - Filmstrip.
7. Samples of Materials - The Celotex Corporation: Samples of various kinds of wall-insulating materials.
8. Pamphlets.
   a. The Carrier Corporation, 850 Frelinghuysen Ave., Newark, N. J.: "Illustrated Pamphlets on Air-Conditioning."
   b. The Celotex Corporation, 919 N. Michigan Ave., Chicago, Illinois: "Home Insulating."
9. Davis, Ira C., and Richard W. Sharpe, Science. New York: Henry Holt and Co., 1936.
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[illegible]. Craig, Gerald S., Science for the Elementary School Teacher. Boston: Ginn and Company, 1940.

[illegible]

1. [illegible] in the [illegible] while studying the unit? — Yes No
2. [illegible] — Yes No
3. [illegible] enjoy [illegible] classroom references? — Yes No
4. [illegible] unit [illegible] your needs? — Yes No
5. [illegible] more or less pupil activity? — Yes No
6. [illegible] interest [illegible] very long before [illegible] action? — Yes No
7. [illegible] optional work challenging? — Yes No
8. [illegible] optional activities interesting? — Yes No
9. [illegible] plan tend to encourage copying? — Yes No
10. [illegible] too much time spent on unimportant facts? — Yes No
11. [illegible] you able to study without waste of time? — Yes No
12. [illegible] you have [illegible] part in the pooling and sharing of experiences? — Yes No
13. [illegible] you able to understand the references studied? — Yes No
14. [illegible] the study guide a help to you? — Yes No
15. Do you enjoy working at your own rate of speed? — Yes No
16. [illegible] the teacher help you much during the laboratory period? — Yes No
17. [illegible] the directions for study clear and helpful? — Yes No
18. Is unit work better than the usual method? — Yes No
19. [illegible] there too much written work? — Yes No
20. [illegible] did you enjoy most in the unit?

21. [illegible] did you dislike the most?

22. [illegible] did you find the easiest?

23. [illegible] did you find the hardest?

24. [illegible] did you find the most valuable?

100%
S.O.
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Johnson, W.M.
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